Overview of Today’s Lecture

- Review of Respiratory System
- Clinical Manifestations of Lung Disease
- Upper respiratory tract diseases & infections
- Atelectasis (lung collapse)
- Pulmonary Edema
- Acute Respiratory Distress Syndrome (ARDS)
- Obstructive Lung Disease
- Restrictive Lung Disease
- Vascular/circulatory lung diseases
- Pneumonia
- Lung Cancer
- Pleural disease

Mechanisms that prevent alveoli from filling with fluid:
1. Cells of alveolar wall are tightly bound together
2. The relatively high osmotic pressure of the interstitial fluid draws water out of fluid
3. There is low hydrostatic pressure in the pulmonary circuit
Mechanics of Breathing

- Major and accessory muscles:
  - Major muscles of inspiration:
    - Diaphragm
    - External intercostals
  - Accessory muscles of inspiration:
    - Sternocleidomastoid muscle
    - Scalen muscles
  - Accessory muscles of expiration:
    - Abdominal intercostal muscles
    - Internal intercostal muscles

Figure from: Huether & McCance, *Understanding Pathology*, 5th ed., Elsevier, 2012

Mechanics of Breathing

- Alveolar surface tension and ventilation
  - Function of surfactant
- Elastic properties of the lung and chest wall:
  - Elastic recoil
  - Compliance
- Airway resistance
- Work of breathing

Figure from: Huether & McCance, *Understanding Pathology*, 5th ed., Elsevier, 2012

General Conditions for Normal Ventilation

- Air must move freely through respiratory passages
- Alveoli must be open
- Must be sufficient pulmonary (respiratory) membrane to exchange gases
- Interstitium of respiratory membrane must be thin enough to allow rapid gas exchange
Spirometry

Pulmonary Tests: Restrictive vs. Obstructive Disease

Obstructive Disease: Greatly decreased FEV₁/FVC

Restrictive Disease: Approximately normal FEV₁/FFV
(However both volume and flow rate are reduced)

In BOTH diseases: O₂ and CO₂ exchange are limited

General Conditions for Normal Ventilation

• Air must move freely through respiratory passages

• Alveoli must be open

• Must be sufficient pulmonary (respiratory) membrane to exchange gases

• Interstitium of respiratory membrane must be thin enough to allow rapid gas exchange
Diseases of the Upper Respiratory Tract

- Sinusitis: acute, chronic (may be caused by mucocele), sinonasal papillomas
- Sinonasal papillomas
- Infectious rhinitis
- Allergic rhinitis: when chronic, can lead to nasal polyps
- Pharyngitis: tonsillitis
- Laryngitis: Vocal Cord Nodules, Laryngeal papillomas, Laryngeal carcinoma

**Note that your textbook considers the larynx as part of the upper respiratory tract.**

General Signs/Symptoms of Pulmonary Disease

- **Dyspnea**
  - Subjective sensation of uncomfortable breathing
  - Orthopnea
    - Dyspnea when a person is lying down
    - Paroxysmal nocturnal dyspnea (PND)
- **Cough**
  - Acute cough
  - Chronic cough
- **Abnormal sputum** (amount, color, consistency)
- **Hemoptysis** (expectoration of blood/secretions)
- **Abnormal breathing patterns:**
  - Kussmaul respirations (hyperpnea)
  - Cheyne-Stokes respirations

General Signs and Symptoms of Pulmonary Disease

- Hypoventilation
  - Hypercapnia ($P_{aCO_2} > 44$ mm Hg)
- Hyperventilation
  - Hypocapnia ($P_{aCO_2} < 36$ mm Hg)
- Cyanosis
- Clubbing
- Pain
Atelectasis (Lung Collapse)

- **Atelectasis**
  - Resorption atelectasis - when air is prevented from reaching lung and air in alveoli is reabsorbed
  - Compression atelectasis - pleural fluid/air, abdominal pressure on diaphragm
  - Contraction atelectasis - Scarred tissue in lung or pleura constrict, collapsing the lung

Pulmonary Edema - Pathophysiology

**Pulmonary edema - Excess water in the lungs**

- A restrictive disorder

  - Main symptom: shortness of breath

  - Pulmonary edema
    - Excess water in the lungs
    - A restrictive disorder

  - Pathophysiology
    - Microvascular
      - Pulmonary edema
        - Movement of fluid and proteins from capillary to interstitial space
        - Atelectasis
        - Causes: smoke inhalation, O2 tox, near drowning, sepsis, heroin O/D, DIC, large bone fracture

Acute Respiratory Distress Syndrome (ARDS) - Overview

- **Acute respiratory distress syndrome (ARDS)**
  - Fulminant (rapid onset) form of respiratory failure characterized by
    - acute lung inflammation*
    - diffuse alveolo-capillary injury
  - Medical emergency
  - Injury to the pulmonary capillary endothelium and/or alveoli
  - Inflammation and platelet activation
  - Formation of thick protein membrane
  - Atelectasis
  - Causes: smoke inhalation, O2 tox, near drowning, sepsis, heroin O/D, DIC, large bone fracture
ARDS Manifestations

- Acute respiratory distress syndrome (ARDS)
  - Manifestations:
    - Hyperventilation
    - Respiratory alkalosis
    - Dyspnea and hypoxemia
    - Metabolic acidosis
    - Hypoventilation
    - Respiratory acidosis
    - Further hypoxemia
    - Hypotension, decreased cardiac output, death

ARDS - Pathophysiology

*Acute respiratory failure: Inadequate gas exchange (\(P_{aCO_2} \geq 50\) mm Hg or \(P_{aO_2} \leq 50\) mm Hg, and \(pH \leq 7.25\))

Pulmonary Disorders – Obstructive Disorders

- Obstructive lung disease
  - General barrier to smooth airflow
  - Usually at the level of the smaller bronchial tree
  - **Problem is getting air out (exhalation), not in**
  - Lung volume is NOT affected (thus, ↓ FEV₁/FVC)
  - Common signs and symptoms
    - Dyspnea and wheezing
  - Common obstructive disorders:
    - Obstructive Sleep Apnea
    - Asthma
    - COPD (Emphysema, Chronic bronchitis)
    - Bronchiectasis (chronic, necrotizing dilation of bronchi; always secondary)
    - Cystic fibrosis
Overview of Obstructive Pulmonary Disease

Normal

Chronic Bronchitis

Emphysema

Bronchial Asthma (Chronic asthma, bronchiitis)

Obstructive Pulmonary Disorders – Asthma

Atopic, Nonatopic, Occupational

**Acute asthma can be fatal!

Main pathological changes seen in asthma

Obstructive Diseases - Pathophysiology of COPD

Airway obstruction and airway trapping seen in COPD

Main pathological changes seen in COPD
Obstructive Pulmonary Disorders - Emphysema

- Emphysema
  - Initial lesion in alveoli
  - Destruction of alveolar walls causes large air spaces
  - Decreased surface area for gas exchange
  - Lung volume is NOT affected (thus, ↓ FEV₁/FVC)
  - Common signs and symptoms
    - Dyspnea and wheezing
    - Patients are well-oxygenated, but have a difficult time exhaling ("pink puffers")
    - Characteristic weight loss
    - Imbalance in inflammatory (oxidative) vs. protective (antioxidant) forces
    - Role of alpha 1 antitrypsin (from liver)

Obstructive Pulmonary Disorders - Chronic Bronchitis

- Chronic Bronchitis
  - Initial lesion in bronchi and bronchioles (not alveoli)
  - Chronic productive cough (sputum), 3 consecutive months, two years in a row may lead to emphysema & right-sided HF
  - Lung volume is NOT affected (thus, ↓ FEV₁/FVC)
  - Common signs and symptoms
    - Dyspnea and wheezing
    - Air movement is poor, oxygenation is low, CO₂ is high
    - No weight loss (tend to be “bulker”)
    - “Blue bloaters”

Comparison of Asthma and Chronic Bronchitis

- Asthma and chronic bronchitis have significant overlap in pathology
- Thus, they are grouped into one major category: COPD
Pulmonary Disorders – Restrictive Diseases

- Stiffness of the lungs
  - Limits volume of lung expansion
  - Limits rate of expansion and contraction
- Characterized by
  - Chronic inflammation
  - Fibrosis
  - Stiffening of alveolar interstitium
- Most cases show idiopathic pulmonary fibrosis

Brown Fletcher

Pulmonary Disorders – Restrictive Diseases

- Bronchiolitis
  - Inflammatory obstruction of the small airways
  - Most common in children
  - Occurs in adults with chronic bronchitis, in association with a viral infection, or with inhalation of toxic gases
- Inhalation disorders:
  - Toxic gases
  - Pneumococcal = lung disease from inhaled inorganic dust or fumes
    - Silica (rock or stone dust; silicosis)
    - Asbestos (usually in industrial settings)
    - Coal (black lung disease; anthracosis)
  - Allergic alveolitis
    - Inhaled organic dusts
    - Extrinsic allergic alveolitis (hypersensitivity pneumonitis)
  - Sarcoidosis (granulomatous inflammation; etiology unknown)

Vacular Pulmonary Disorders – Pulmonary Embolus

- Occlusion of a portion of the pulmonary vascular bed
  - Virchow’s triad
  - Venous stasis, hypercoagulability, and injuries to the endothelial cells that line the vessels
  - Thrombus, embolus, tissue fragment, lipids, or an air bubble
  - Pulmonary thromboemboli commonly arise from the deep veins in the thigh
  - Small emboli: Chest pain/cough
  - Large embolus may cause instantaneous death (saddle embolus)
Vascular Pulmonary Disorders – Pulmonary Hypertension

- Mean pulmonary artery pressure 5 to 10 mm Hg above normal or above 25 mm Hg
- Primary pulmonary hypertension
  - Idiopathic
- Diseases of the respiratory system, e.g., COPD and hypoxemia, are more common causes
- Vasospasm and endothelial proliferation gives rise to an ‘onionskin’ endothelial hyperplasia

Pulmonary Disorders – Cor Pulmonale

- Pulmonary heart disease
  - Right ventricular enlargement
  - Secondary to pulmonary hypertension
  - Pulmonary hypertension creates chronic pressure overload in the right ventricle

Pneumonia

- Inflammation of the lungs
- Kills over 50,000 Americans each year
- Pneumonia usually classified by causative agent (if it can be identified)
- When organism cannot be identified, classified by setting in which the pneumonia arose (Community acquired, Nosocomial, Aspiration, Chronic (TB), Immunodeficiency)
- Local respiratory tree defenses (mucociliary system, MALT) can be impaired by:
  - Tobacco smoke, alcohol, toxic gas
  - Genetic defects
  - Accumulation of bronchial mucus & bronchial obstruction
  - Suppression/loss of cough reflex
  - Accumulation of alveolar fluid with pulmonary edema
  - Immunodeficiency
**Pneumonia**

- Occurs in two anatomic forms
- **Alveolar**
  - Acute inflammation filling alveoli with neutrophils
  - Usually bacterial
  - More common than interstitial
  - Includes
    - Bronchopneumonia (more than one lobe, usu patchy)
    - Lobar pneumonia (consolidation of entire lobe) – usual cause is S. pneumoniae
- **Interstitial**
  - Confined to alveolar septa
  - Diffuse inflammation
  - Usually virally caused

---

**Pneumonia**

Respiratory tract infections: pneumonia

- Pneumococcal (main cause of lobar pneumonia)
- Viral

---

**Pulmonary Disorders – Abscess/Cavitation**

- Abscess – circumscribed area of suppuration (pus) and destruction; common in aspiration pneumonia
- Cavitation – abscess emptying into a bronchus and forming cavity
  - Foul-smelling sputum
  - Possible hemoptysis
  - Systemic manifestations
Pulmonary Disorders – Chronic Pneumonia

- Usually due to tuberculosis or deep fungal infection
  - *Mycobacterium tuberculosis* (most commonly)
  - Histoplasma, Blastomyces, Coccidioides (most commonly)
- Candidiasis
  - *C. albicans* (normal oral cavity flora - yeast)
  - Most common form cause of fungal infection
- Cryptococcosis (*C. neoformans*)
  - Common in immunocompromised patients
- Histoplasmosis (*H. capsulatum*)
  - Eastern US
  - Inhalation of bird droppings
- Coccidioidomycosis (*C. immitis*)
  - Western US, Mexico, S. America - in soil

Pulmonary Disorders - Malignancies

- Lung cancer (bronchogenic carcinoma)
  - Arise from epithelial lining of bronchi
  - Most common cause is cigarette smoking (20x risk)
  - Environmental or occupational risk factors are also associated
- Types:
  - Small cell cancer
    - From neuroendocrine tissue; distinctive appearance
    - Paraneoplastic syndrome
    - Very aggressive; poor prognosis
  - Non-small cell cancer (NSCLC):
    - Squamous cell carcinoma (epithelium-like pattern)
    - Adenocarcinoma (glandular pattern)
    - Large cell carcinoma (may be combination of above two)
### Pulmonary Disorders - Malignancies

#### Table 10.1: Carcinoma of the Lung: Prevalence and Survival

<table>
<thead>
<tr>
<th>Type</th>
<th>Small Cell</th>
<th>Non-Small Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenocarcinoma</td>
<td>~15%</td>
<td>~42%</td>
</tr>
<tr>
<td>Squamous cell</td>
<td>~28%</td>
<td>~15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PREVALENCE</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival at Five Years</td>
<td>~62%</td>
<td>~47%</td>
<td>~15%</td>
<td>&lt;7%</td>
</tr>
</tbody>
</table>

#### Pleural Abnormalities

- **Pneumothorax**
  - Abnormal collection of air/gas between pleura and lung
  - May occur spontaneously in otherwise healthy people, e.g., young adult smokers
  - Emphysema
  - Traumatic penetrations or broken ribs
  - **Tension pneumothorax**
    - Air can enter but cannot leave
    - Creates very high pressure that stifles respiratory function
    - Medical emergency

- **Pleural effusion**
  - Accumulation of fluid in pleural space
  - **Inflammatory**
    - Arise from pleural inflammation (pleuritis)
    - Causes localized pain (pleurisy) on breathing
    - May be caused by lung infection spreading to pleura
  - **Noninflammatory**
    - High venous pressure or low osmotic pressure
    - Transudative effusion, e.g., common cause is HF
    - Hemothorax (blood)
    - Empyema (Infected pleural effusion)
    - Chylothorax (presence of chyle)